Transitioning from Design Reviews to the SIR Hardware Review

Randall Taylor
GRAIL Project Acquisition Manager/
Review Captain
Jet Propulsion Laboratory
California Institute of Technology

2011 IEEE Aerospace Conference

March 5–12, 2011

The GRAIL Mission

- The Gravity Recovery And Interior Laboratory (GRAIL) mission was selected by NASA as a Discovery Program project
- GRAIL is PI-led (Dr. Maria T. Zuber, MIT) and JPL-managed
- Key development dates:
  - Jan. 2008: Start of Phase B
  - Apr. 2008: Project Mission System Review (PMSR)
  - Nov. 2008: Project Preliminary Design Review (PDR)
  - Jan. 2009: Confirmation Review/Key Decision Point (KDP)-C
  - Mar. 2009: Start of Phase C
  - Nov. 2009: Project Critical Design Review (CDR)
  - Jun. 2011: Project System Integration Review (SIR)
  - Jul. 2011: Start of Phase D

- Science objectives:
  - Determine structure and interior of the Moon, from crust to core
  - Understand thermal evolution of the Moon
  - Extend knowledge to other terrestrial planets
- Mission outline:
  - Twin spacecraft launched on a Delta 7920H-10
  - 9-month mission; launch in Sept 2011
  - Low altitude, 50-km polar orbit
  - 82-day primary mapping mission
  - Spacecraft operates at ~200 km separation
  - Extensive science data analysis
  - E/PO MoonKAM cameras engage public
  - Heritage: GRACE-like mission concept
  - Heritage: Spacecraft from LM: XSS-11 and MRO

- Science measurements and payload:
  - Ka-band ranging system (with GRACE heritage) measures relative velocity of CM of two spacecraft
  - DSN used for absolute position determination
- Mission management:
  - MIT: PI, SRS contract for E/PO
  - GSFC: Gravity science modeling and data analysis
  - JPL: PM, SE, MA, MO and GDS, payload, LM spacecraft system contract, data processing
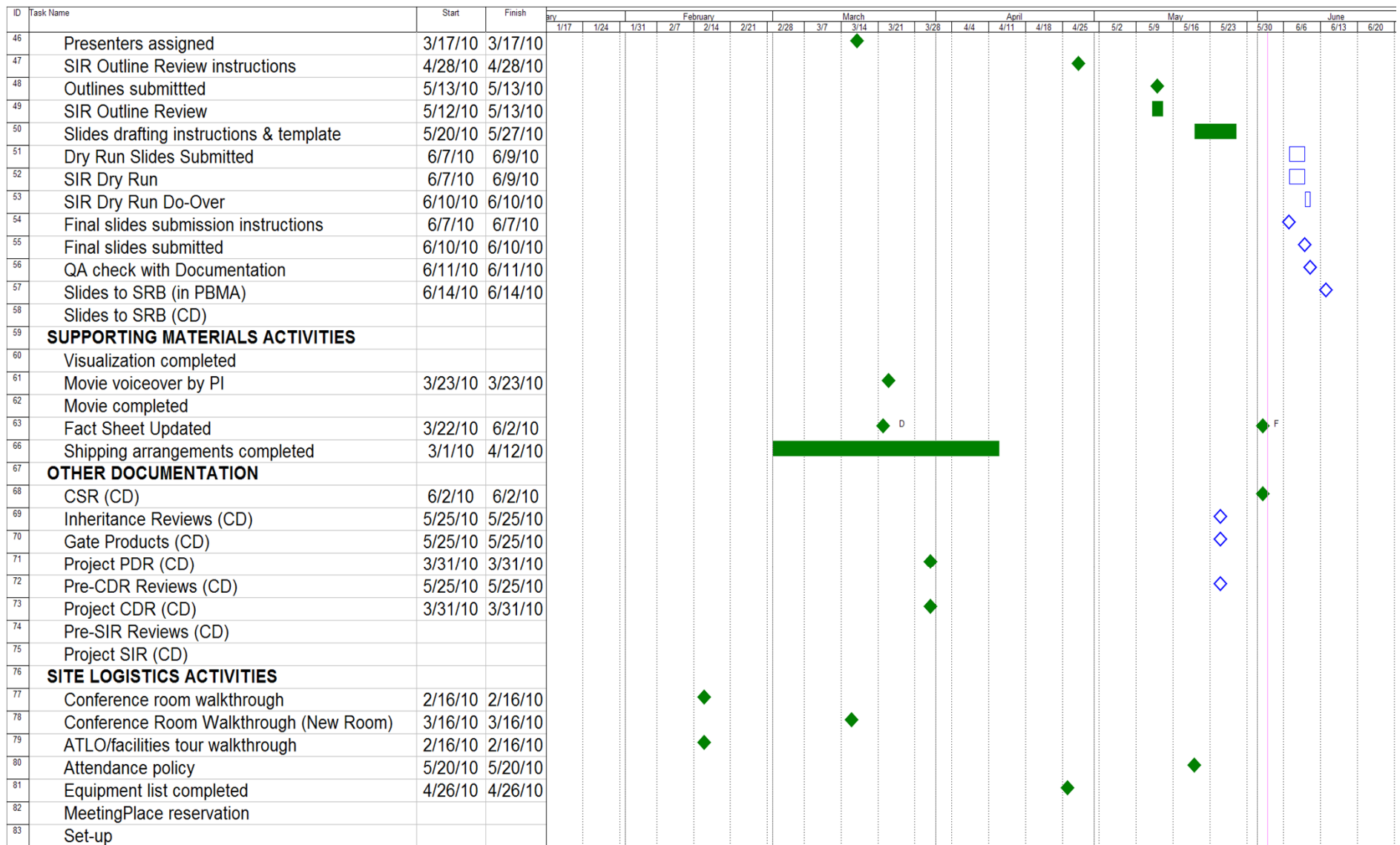
- The project established a review preparation team with key roles:
  - Review Captain
    - Team leader
    - Lead for gate products and presentation materials instructions, guidelines, interpretations, content review
    - Supported by project schedule analyst
  - Documentation Lead
    - Lead for gate products and presentation materials formatting, editing, production
    - Supported by other technical writers and reproduction contractor
  - Information Systems Lead
    - Lead for file formats, data repositories, access privileges, and IT requirements
    - Supported by project librarian and CM engineer at JPL, and IT Coordinator at LM
  - Logistics Lead
    - Lead for logistics actions and for logistics requirements
- The team employed a detailed preparation schedule to make sure all actions were identified, assigned, and completed on time

ID	Task Name	Start	Finish
1	**GRAIL**	**1/29/10**	**6/14/10**
2	**REVIEW BOARD ACTIVITIES**	**1/29/10**	**6/1/10**
3	CDR RFA closures submitted	1/29/10	5/3/10
8	SRB concurs on closures	5/21/10	5/21/10
9	Draft Terms of Reference (ToR) SIR Appendix	3/1/10	3/1/10
10	ToR Appendix accepted by SRB	3/30/10	3/30/10
11	ToR Appendix signed	4/14/10	6/1/10
12	Draft SIR Agenda (summary agenda)	3/19/10	3/19/10
13	SRB accepts Agenda	5/3/10	5/3/10
14	Draft documentation submission schedule	5/19/10	5/19/10
15	SRB accepts documentation schedule	5/27/10	5/27/10
16	SRB Kickoff Meeting support (if requested)		
17	**GATE PRODUCTS ACTIVITIES**	**1/29/10**	**6/11/10**
18	Assign SIR gate products	2/26/10	2/26/10
19	Issue drafting instructions	4/5/10	4/15/10
20	Clarify gate products content	1/29/10	5/3/10
21	Drafts to Documentation Services	5/3/10	5/18/10
22	Issue submittal/signature instructions	4/15/10	4/15/10
23	Submission of draft documents	5/10/10	6/10/10
24	Project review completed	5/10/10	6/10/10
25	CCBs completed	5/13/10	5/13/10
26	Documents signed	5/24/10	5/24/10
27	CADRe to IPAO	5/24/10	5/24/10
28	EVM data to IPAO	5/25/10	5/25/10
29	Cost/Schedule Assessment data to IPAO	5/25/10	6/3/10
32	**Risk List to SRB**	**5/19/10**	**6/3/10**
35	Gate products to SRB (in PBMA)	5/24/10	6/11/10
40	Gate products to SRB (CD) -- TBN		
41	**PRESENTATION SLIDES ACTIVITIES**	**3/9/10**	**6/14/10**
42	SIR key messages	3/9/10	4/2/10
43	SIR key messages update	5/21/10	5/21/10
44	Draft detailed SIR Agenda	4/23/10	4/23/10
45	Final detailed SIR Agenda	5/13/10	5/13/10

ID	Task Name	Start	Finish
46	Presenters assigned	3/17/10	3/17/10
47	SIR Outline Review instructions	4/28/10	4/28/10
48	Outlines submittted	5/13/10	5/13/10
49	SIR Outline Review	5/12/10	5/13/10
50	Slides drafting instructions & template	5/20/10	5/27/10
51	Dry Run Slides Submitted	6/7/10	6/9/10
52	SIR Dry Run	6/7/10	6/9/10
53	SIR Dry Run Do-Over	6/10/10	6/10/10
54	Final slides submission instructions	6/7/10	6/7/10
55	Final slides submitted	6/10/10	6/10/10
56	QA check with Documentation	6/11/10	6/11/10
57	Slides to SRB (in PBMA)	6/14/10	6/14/10
58	Slides to SRB (CD)		
59	**SUPPORTING MATERIALS ACTIVITIES**		
60	Visualization completed		
61	Movie voiceover by PI	3/23/10	3/23/10
62	Movie completed		
63	Fact Sheet Updated	3/22/10	6/2/10
66	Shipping arrangements completed	3/1/10	4/12/10
67	**OTHER DOCUMENTATION**		
68	CSR (CD)	6/2/10	6/2/10
69	Inheritance Reviews (CD)	5/25/10	5/25/10
70	Gate Products (CD)	5/25/10	5/25/10
71	Project PDR (CD)	3/31/10	3/31/10
72	Pre-CDR Reviews (CD)	5/25/10	5/25/10
73	Project CDR (CD)	3/31/10	3/31/10
74	Pre-SIR Reviews (CD)		
75	Project SIR (CD)		
76	**SITE LOGISTICS ACTIVITIES**		
77	Conference room walkthrough	2/16/10	2/16/10
78	Conference Room Walkthrough (New Room)	3/16/10	3/16/10
79	ATLO/facilities tour walkthrough	2/16/10	2/16/10
80	Attendance policy	5/20/10	5/20/10
81	Equipment list completed	4/26/10	4/26/10
82	MeetingPlace reservation		
83	Set-up		

- As proposed, GRAIL conducted a battery of pre-SIR reviews
  - Reviews included project, payload, spacecraft, and mission system reviews:
    - Dec '09 – Completed Avionics Delta CDR
    - Jan '10 – Launch Loads Review (decision to add SoftRide)
    - Feb '10 – GDS Peer Review
    - Feb '10 – MOS Peer Review
    - Mar '10 – MOS Staffing Review
    - Apr '10 – GDS 2.0 Delivery Review
    - Apr '10 – Pre-SIR V&V Peer Review
    - May '10 – MOS CDR
    - May '10 – SoftRide PDR
    - Jun '10 – SoftRide CDR
    - Jun '10 – Science Modeling Peer Review
- All reviews had board reports, Recommendations for Action (RFAs), and project responses

- NPR 7120.5D specifies gate products and control plans for KDP D; NPR 7123.1 specifies (explicit or implied) gate products as entrance criteria for the review
- JPL Flight Project Practices requires extensive gate products at SIR
  - Fewer in number than for CDR– and many were updates of CDR deliverables
- Gate product content and format are not always clear
  - GRAIL Review Captain and JPL Project Support Office provided instructions and made interpretations, as required
  - In many cases NASA or JPL templates exist (e.g., NASA 7120.5D template for Project Plan, JPL template for Project Acquisition Plan)
  - In other cases NASA or JPL instructions exist (e.g., NASA Safety Standard instructions for orbital debris assessment)
  - Also available were examples from other projects (e.g., Juno's Science Data Mgmt. Plan)
- Product generation instructions were issued
- GRAIL developed a detailed tracking matrix to ensure all gate products were identified, assigned, reviewed, and signed in a timely manner (see Backup slide)
- Review Captain determined methods for project internal review
- Documentation Lead provided GRAIL-formatted document shells, and her team provided custom graphics, technical editing, etc., as requested by the authors
- Logistics Lead coordinated signatures, both on-site and remotely from a nationally distributed team
- Project Librarian uploaded signed documents to the SRB's repository (PBMA)

- GRAIL took a thoughtful approach to defining the SIR agenda
  - Each day of the review had a theme:
    - Day 1: Project status
    - Day 2: Hardware status
    - Day 3: ATLO readiness
- The project employed an Outline Review well in advance
  - To make decisions early—no text slides allowed!
    - Presenters brought in stub slides (title, key points, identification of photos/tables/graphics/video clips/etc.)
    - Results: moved material between presentations or to backup (or primary); revised flow of presentations (delta agenda); adjusted time allocations; identified slide types for standardization
- Issued slide generation instructions (including template slides)
- Followed by a multiday Dry Run (including a "do-over day')
  - Export compliance check performed in real time (by trained project personnel)
- Issued finalization and submission instructions
- Final slides given QA check/correction by Review Captain, Documentation Lead

- Design discussion would be limited to reporting on design maturity (e.g., requirements table indicating TBXs), summary of closed trade studies and explanation of any ones remaining open, significant ECRs since the CDR, etc.
  - SRB is not interested in elegance of design at this stage
  - Do demonstrate robust technical resources margins
- Hardware discussion would emphasize production status, issues, and work plan to start of system integration testing (SIT)
  - Report on unit-level and higher testing, completed and planned
- Hardware/software would declare, in one easy-to-use table, "open paper" status, with supporting work-off plan for any item(s) not yet complete that were a constraint to start of SIT (see next slide)
  - This proved a big hit (Note: transparency can make you look awfully good or awfully bad!)

Telecom Open Paper Status

Item	Status	Closure
Requirement	All L4 requirements complete; no TBDs.	Closed
Verification Methods	All verification methods are identified.	Closed
ICDs/MICDs	All ICDs and MICDs are complete.	Closed
Reliability Analysis	All reliability analyses complete except: Transponder Electrical Parts Stress Analysis Transponder WCA	June 25, 2010 July 12, 2010
Parts List Approvals	All EEE Parts Lists and MIULs complete.	Closed
Engineering Drawings	N/A	N/A
RFA Closures	All Telecom Subsystem RFAs are closed.	Closed
Change Requests	All ECRs have been incorporated.	Closed
Waivers*	All waivers submitted except: Transponder EPSA Waivers LGA Boresight Gain Waiver	June 16, 2010 August 4, 2010
GIDEP Review	All GIDEP reports are dispositioned.	Closed

* Remaining waivers considered low risk

Schmitzer   13-8

IT and Logistics

- IT needs to be designed-in from the beginning
  - Engineering environment for project work (e.g., project library, Product Data Management System, electronic conferencing, etc.)
  - Access controls (including participation of foreign persons)
- For the SIR, identify the equipment (with backups) and the operators
  - Cover project needs, SRB needs, and attendee needs
- Logistics must start early
  - Key decision: Review on-base or off? (Book early)
  - Arrange facility, equipment, technical support, administrative support
  - Key decision: Who should and should not attend?
    - Include precautions for Foreign Persons
- There are a large number of "little things" that all must be done or the problems won't be little: Have a checklist

SRB Coordination

- The NPR 7120.5B SRB process is in some regards still a work in progress
  - 7120.5D provides the concept and the deliverables
- The SRB Handbook provides some how-tos
  - The Decision Authorities and the SRB Chairperson and Review Manager (RM) have significant leeway regarding "how" and "when"
- Absolutely critical: Start the board-establishment process six months in advance of the first life-cycle review (GRAIL did not and was significantly impacted)
- Almost as critical: start the draft Terms of Reference (ToR) while the nominations are being processed.
  - Key elements to negotiate:
    - Scope of review (any special assessments)
    - Advance documentation deliveries (including schedule)
    - Participation of SRB members in project-internal reviews
  - We did all these and still held the first life-cycle review without a signed ToR
- Establish regular communication with the SRB Chairperson and RM
  - Set up the repository for project deliveries to the SRB
  - How you deal with the SRB before the review makes your first impression
- Having SRB members participate in the pre-SIR reviews was very helpful
  - Pre-educates the board; provides insight into care-abouts and concerns

Summary

- "Haste makes waste": Beginning late on preparations for a life-cycle review is asking for trouble
- Although the SRB process is evolving, the essentials of preparing for a life-cycle review are clear
  - Establish a review organization with clear roles and responsibilities
  - Identify all required activities and have a detailed schedule
  - Determine how to handle pre-SIR reviews, gate products, presentation materials, IT, and logistics
  - Establish the SRB, and your relationship with it, early and clearly
- Leverage institutional resources and learn from other projects
- More information is available in the IEEE paper "Reducing NPR 7120.5D to Practice: Transitioning from Design Reviews to the SIR Hardware Review"

- GRAIL CDR Gate Products (extract)

JPL Gate Products

Seq Number		PRODUCTS	KEY LIFE-CYCLE MILESTONES				Assigned to	Due Date	Status	Comments
			MDR/PMSR	PDR	Proj/Sys CDR	SIR				
Nominal timing is shown. Projects with system contracts may need to prepare documents required for the RFP earlier, as appropriate.										
Project Systems Engineering										
PSE	1	Planetary Protection Category letter	NASA approval requested			<resubmit>	Lehman ©		SIGNED	Completed at PDR or earlier, but needed re-submit due to new NASA Category for lunar missions (new UN Treaty).
PSE	2	Project Level 2 Requirements	Preliminary	Final			Gounley ©	NA	<completed at CDR or earlier>	Title is Project Requirements Document. Updated version from DOORS
PSE	3	Project library & MCDL established	Operational				Reiz ©	NA	<completed at PDR or earlier>	
PSE	4	Project Verification & Validation results					NA	NA	NA	Not due until after SIR
PSE	5	Inter-system (flight-ground) interfaces		Draft ICDs	Final ICDs		Gounley ©	NA	<completed at CDR or earlier>	Title is Flight-Ground Interface Control Document
		EEIS Phased Development & Test Plan				<final>	Lock ©		SIGNED	Title is Preliminary EEIS Phased Development and Test Plan
		EEIS Concept					Lock ©	NA	<completed at CDR or earlier>	
PSE	6	Significant Risk List	Preliminary	Baseline		<updated>	Price ©		SUBMITTED May Risk Board version, updated with June Board version	
		Project Risk List				<updated>	Price ©		SUBMITTED May Risk Board version, updated with June Board version	
PSE	7	Probabilistic Risk Assessment (for Category I and Risk Class A projects only)		Initial PRA	Updated PRA		NA	NA	NA	GRAIL is not Cat. 1 or Class A
PSE	8	Functional FMECA (Risk Class A projects only)		Preliminary	Final		NA	NA	NA	GRAIL is not Cat. 1 or Class A
PSE	9	Orbital Debris Compliance Assessment	Initial	Preliminary	Final		Ratliff ©	NA	<completed at CDR or earlier>	Title is Orbital Debris Assessment Report
		End of Mission Plan					Ratliff ©	NA	<completed at CDR or earlier>	